SAFETY OF THREATENED BUILDINGS PROGRAM

Annual Fire Conference

Building and Fire Research Laboratory
National Institute of Standards and Technology

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NIST
National Institute of Standards and Technology
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What is the *Safety of Threatened Buildings Program*?

Part of the NIST post-9/11 response plan and an extension and enhancement of pre-9/11ongoing R&D

Objective: **To provide a technical foundation that supports improvements to codes, standards, and practices that reduce the vulnerability of structures, building occupants and first responders to extreme threats.**

Anticipated Major Outcomes:

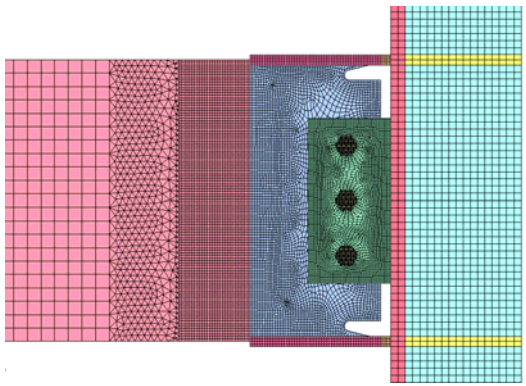
A. **Increased Structural Integrity**
B. **Enhanced Fire Resistance**
C. **Improved Emergency Egress & Access**
D. **Building & Emergency Equip. Standards & Guidelines**

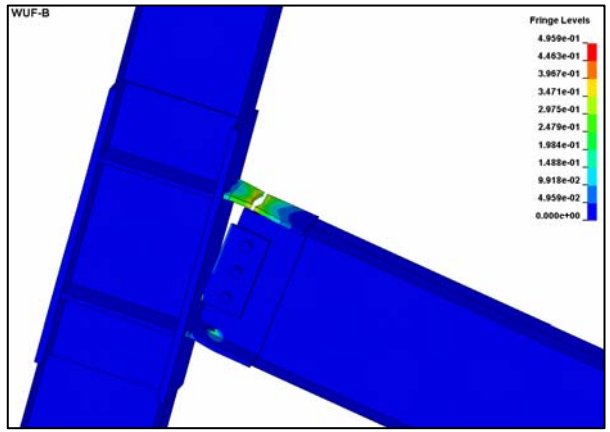
A. Increased Structural Integrity

A1. Prevention of Progressive Collapse

Research Objective: To develop performance criteria for prevention of progressive structural collapse (failure of system disproportionate to localized triggering event).

Computer model for the beam-column connection to predict behavior before test





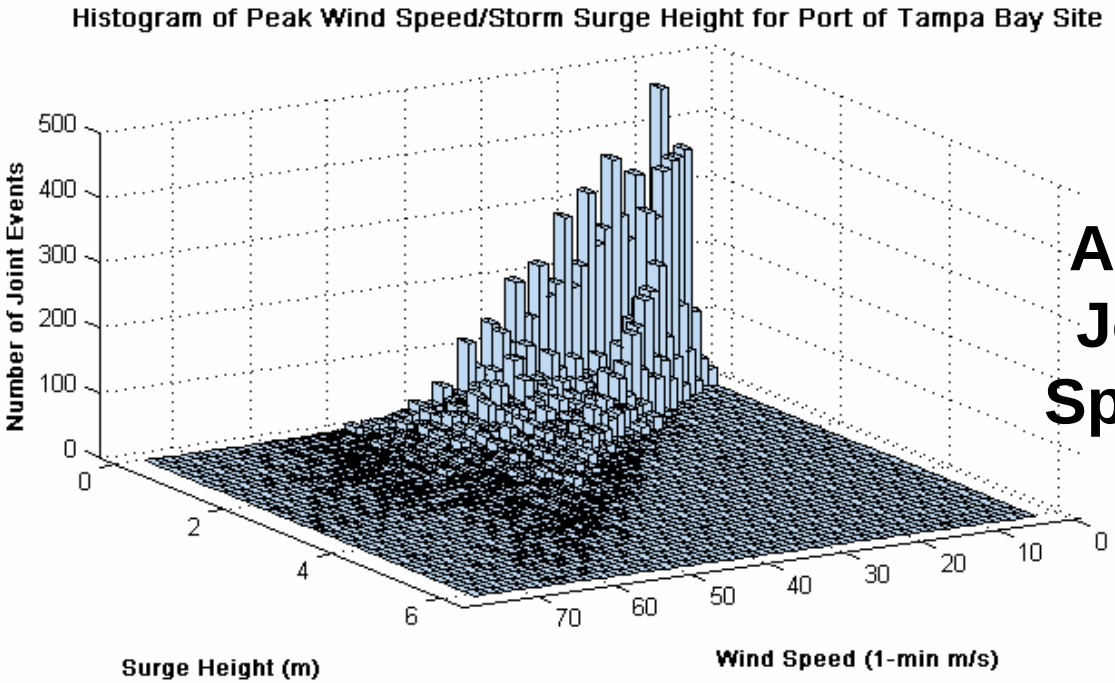
Computer simulation of beam failure before test

Post failure of the same connection

A. Increased Structural Integrity

A2. Wind Loads on Buildings

- Buildings are designed largely by using 19th century principles and criteria.
- Safety levels under fire and wind need to be predicted realistically and consistently.
- Failure modeling tools for use by engineering firms are needed for ensuring inherently safe designs, based on realistic physical models.



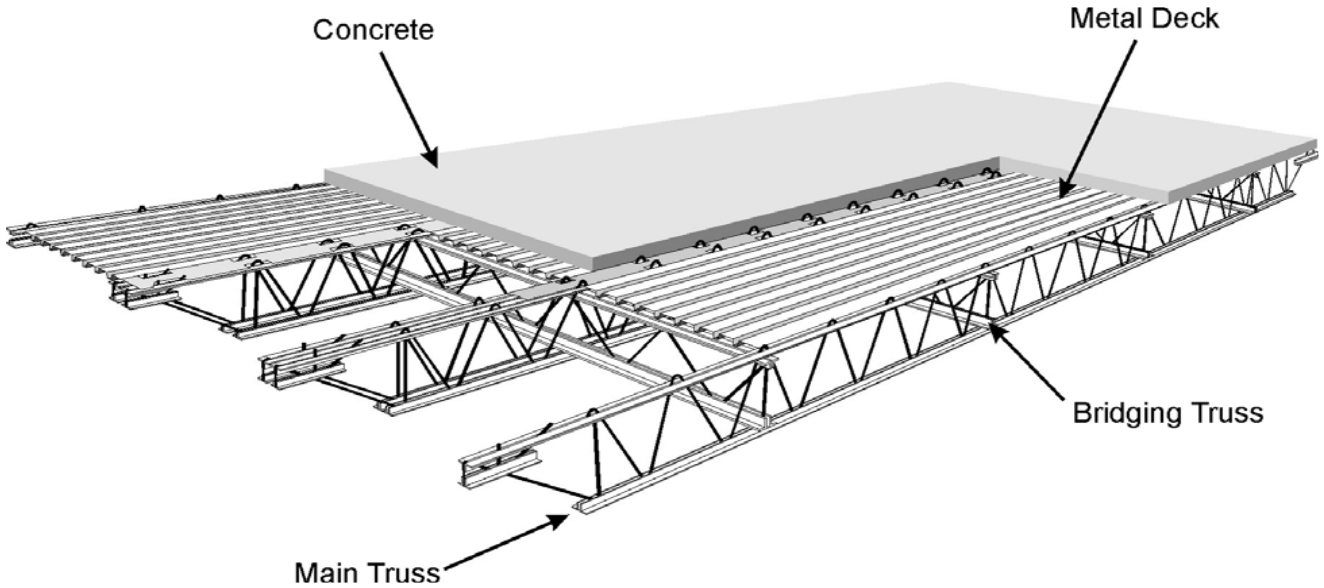
A3. Design Criteria for Joint Hurricane Wind Speed and Storm Surge

A. Increased Structural Integrity

A4. Fire Safe Building Structures

To develop and implement verified and improved standards, tools, methodology and guidance for the fire safety design and retrofit of structures.

- National R&D Roadmap for Structural Fire Safety Design and Retrofit of Structures
- Furnace testing of composite concrete slab/steel truss floor system

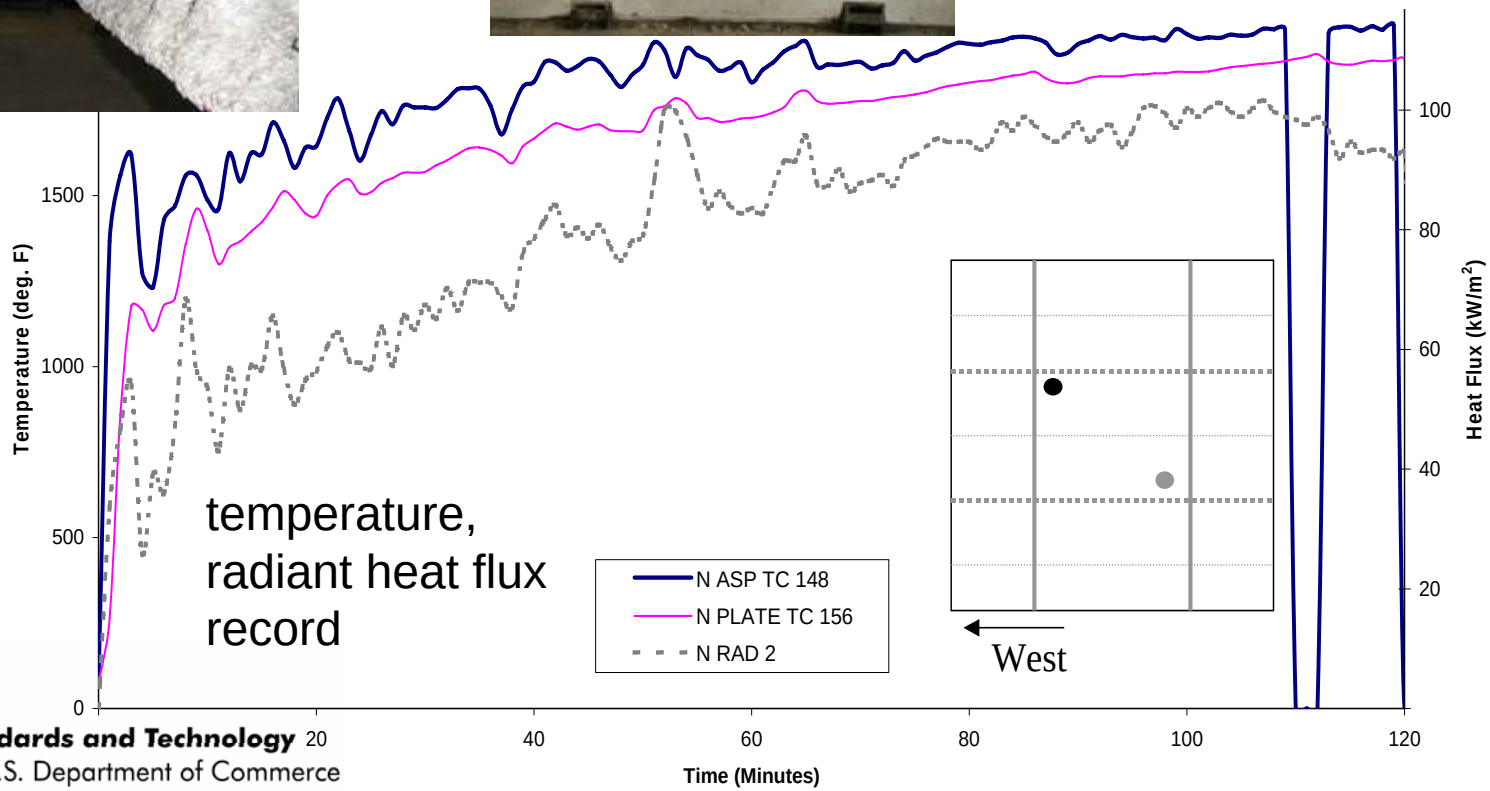


A4. Fire Safe Building Structures

Fire resistance testing of loaded composite floor systems

post-test, local buckling of truss members

post-test, concrete spalling delamination



temperature, radiant heat flux record

A4. Fire Safe Building Structures

Fire resistance testing of loaded composite floor systems

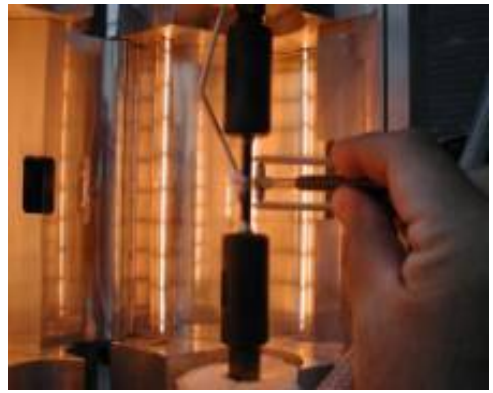
Summary of ratings:

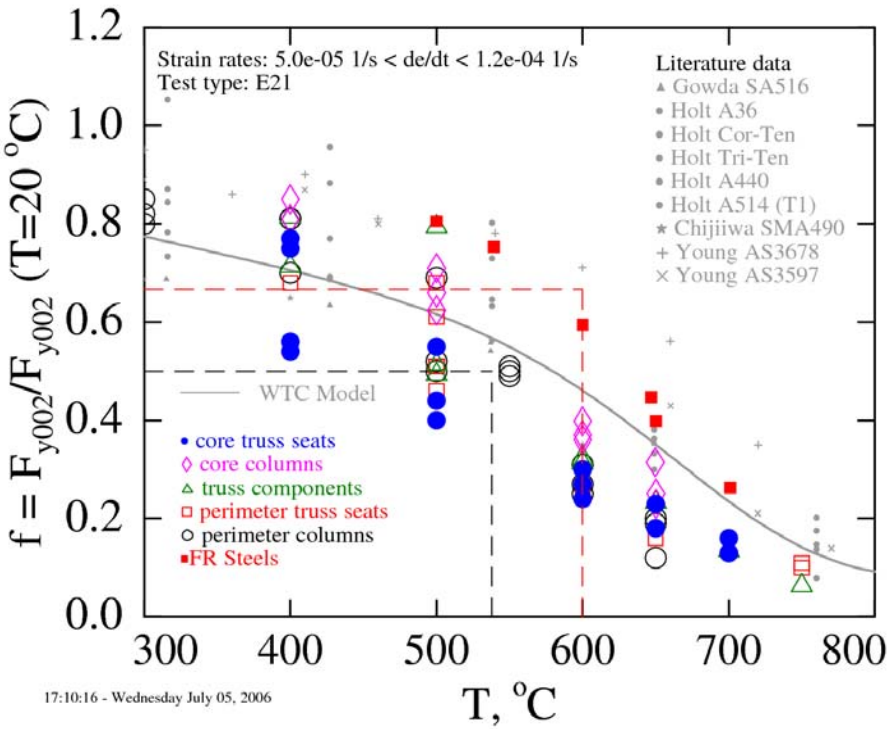
Description	Mode of failure (time, minutes)	Restrained Rating	Unrestrained Rating
10.6 m, restrained 19 mm SFRM	exceeded 205 °C on top surface (111 minutes)	1½ hr	1 hr
10.6 m, unrestrained 19 mm SFRM	exceeded deflection limit of furnace (146 minutes)	---	2 hr
5.2 m, restrained 19 mm SFRM	exceeded 205 °C on top surface (157 minutes)	2 hr	1 hr
5.2 m, restrained 12 mm SFRM	exceeded 205 °C on top surface (58 minutes)	¾ hr	¾ hr

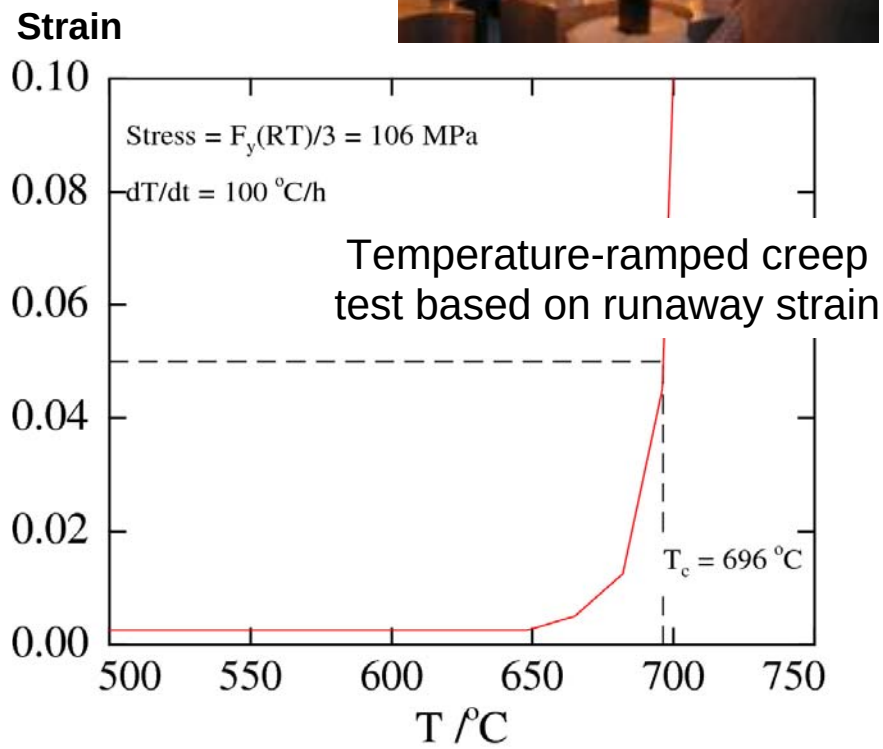
B. Enhanced Fire Resistance

B1. Fire Resistance of Bare Structural Steel

- Develop and standardize test method for evaluating fire resistance of structural steel.
- Produce validated database of mechanical properties for several common construction steels.





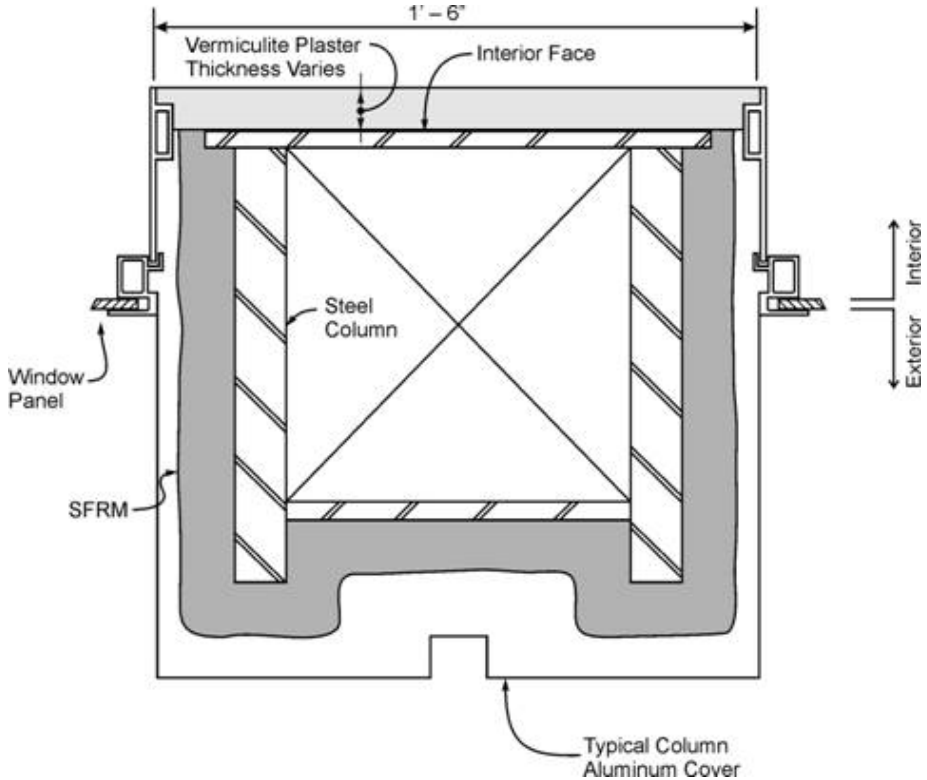


B. Enhanced Fire Resistance

B2. Fire Resistive Coatings for Structural Steel

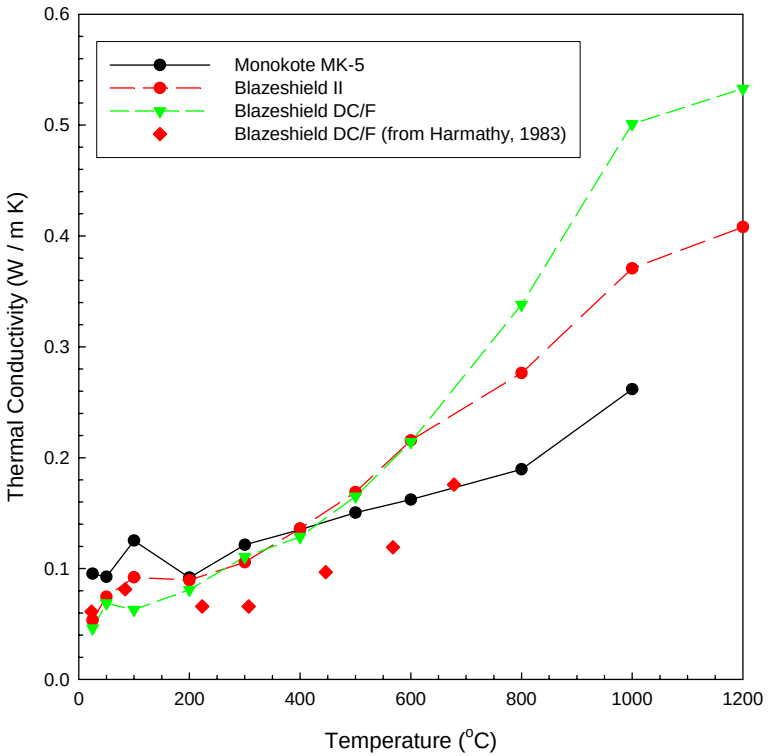
Goal: To introduce materials science to the FRM industry, focusing on

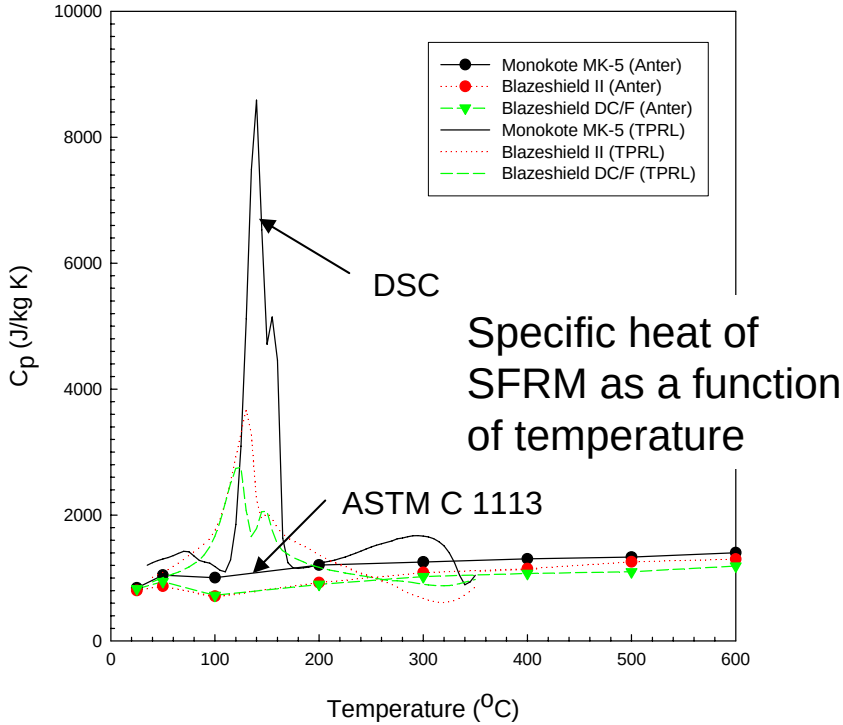
- adhesion
- microstructure
- thermophysical properties



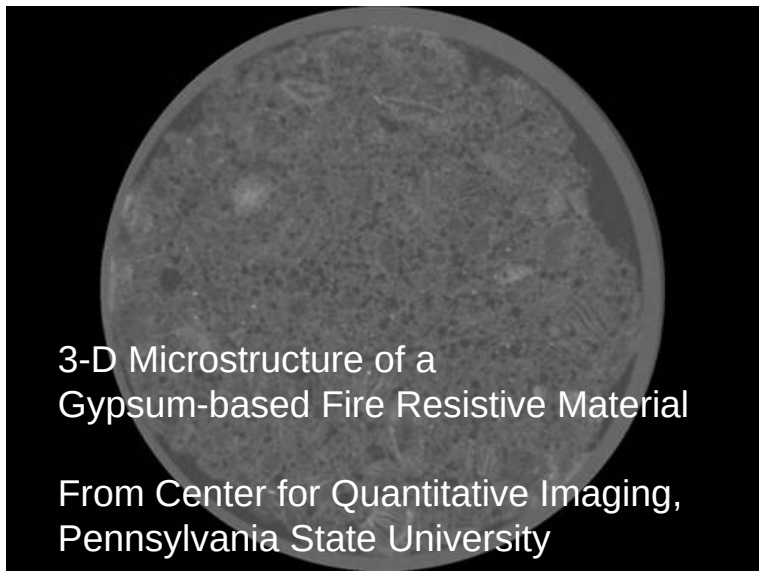
B2. Fire Resistive Coatings for Structural Steel

Thermal conductivities of the three SFRMs as a function of temperature





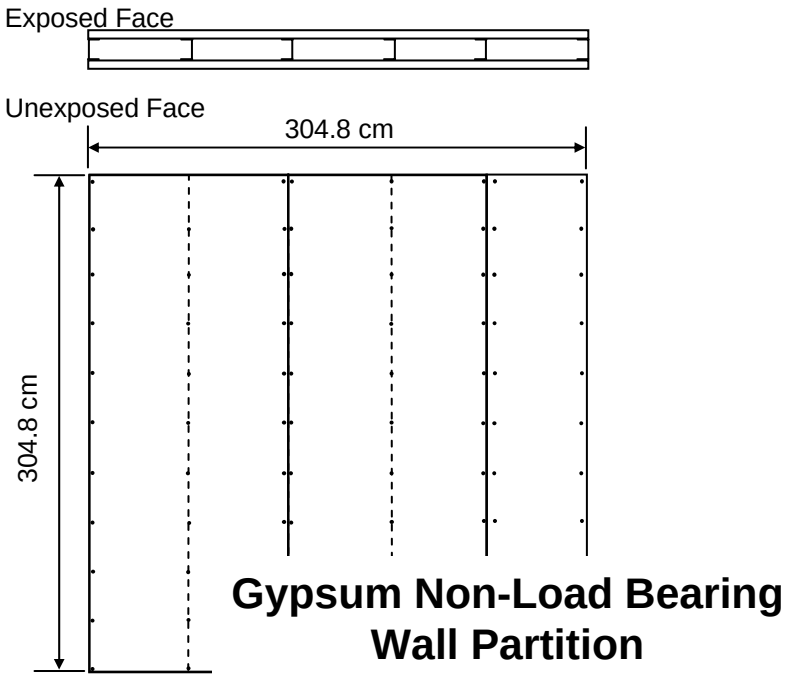
Specific heat of SFRM as a function of temperature



B. Enhanced Fire Resistance

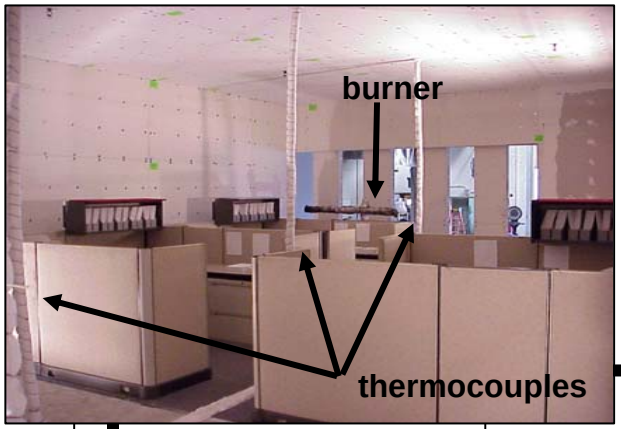
B3. Performance of Structural Elements Exposed to Real Fire Exposures

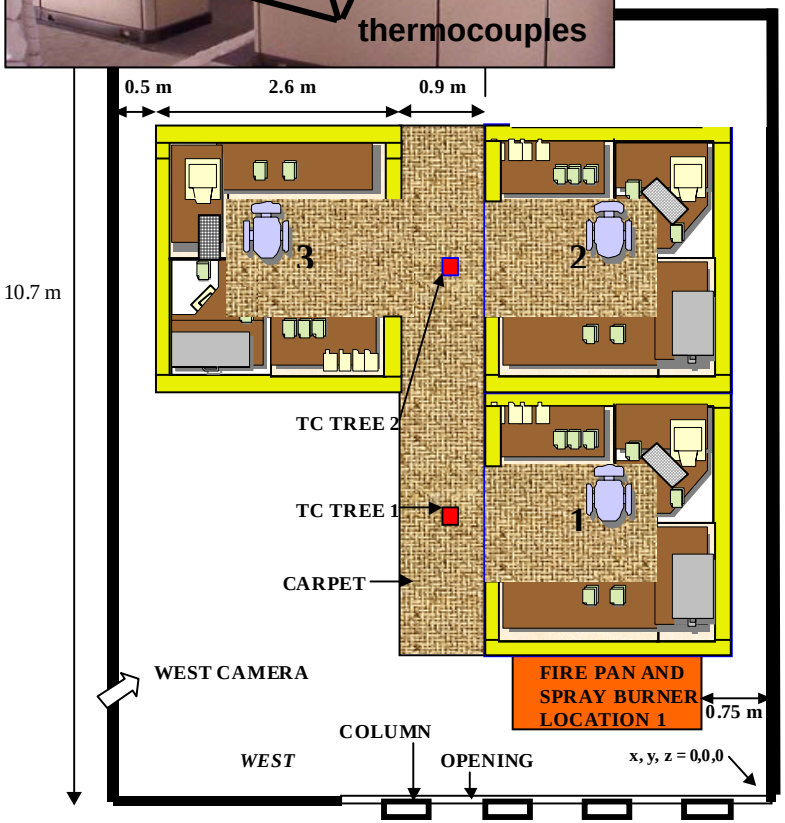
- Full-scale tests of wall assemblies to investigate failure
- Full-scale furnace tests under NAFTL to compare failure modes
- Reduced-scale tests for insight into contraction/cracking/failure
- Results used to validate model of partition assembly failure

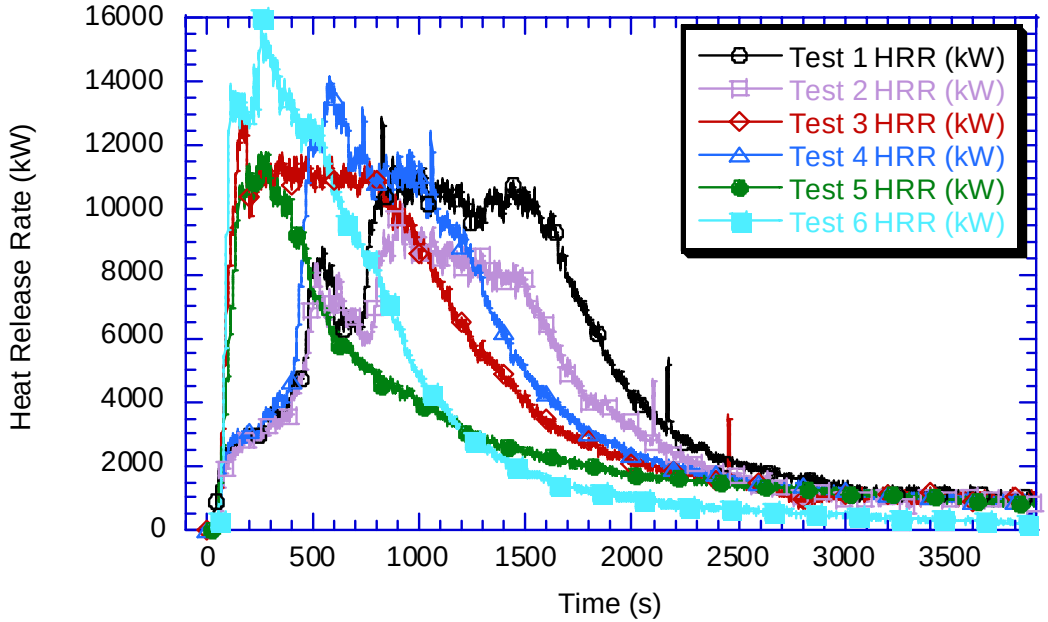


Gypsum Non-Load Bearing Wall Partition

B3. Performance of Structural Elements Exposed to Real Fire Exposures



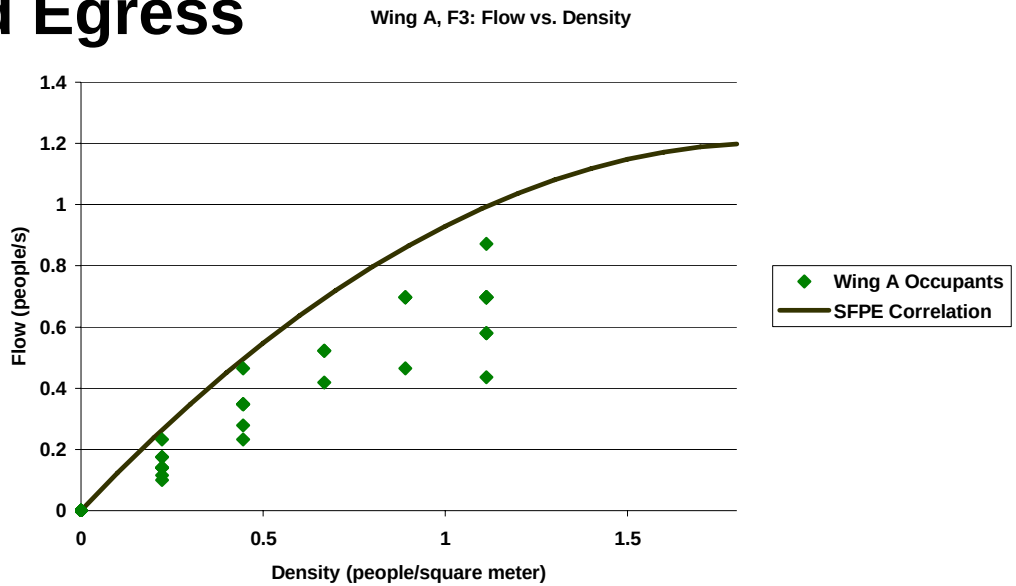


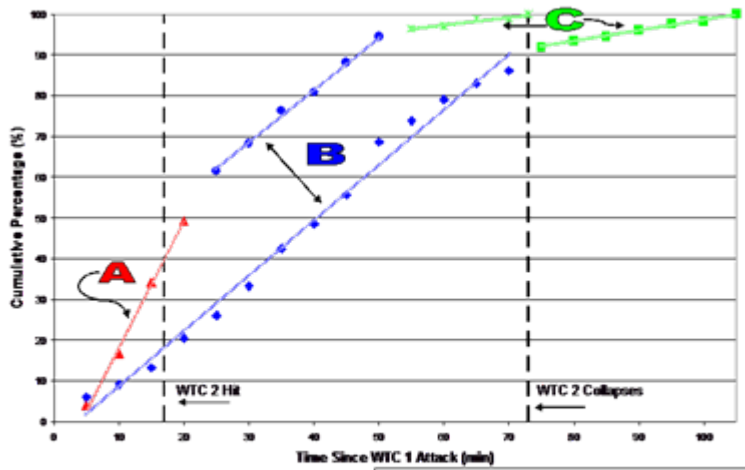


C. Improved Emergency Access and Egress

C1. Occupant Behavior and Egress

- Video monitoring for data collection and analysis
- Pre-evacuation activities, speed, flow, density on stairwells and horizontal surfaces, merging flows, responder counterflow
- Fire Drills – 13 Story mid rise baseline (~300 occupants), 6 Story with/without counterflow (~8,000 occupants)
- Analysis of Actual Events – WTC, Rhode Island Nightclub





- A – Elevator use doubles exit rate compared to stairs only
- B – Exit rate similar using stairs only
- C – Rate slows ~ 20 minutes prior to collapse for WTC 1 and WTC 2

C2. Emergency Use of Elevators

Fire Service Access:

- ASME/NIST/Industry task group to develop requirements for ASME A17.1 near completion.
- Coordinated code changes submitted to ICC and NFPA in current cycle.

Occupant Egress:

- ASME/NIST/Industry task group to develop requirements for ASME A17.1; should complete work by late 2007.
- Coordinated code changes to be submitted to ICC and NFPA for next cycle.

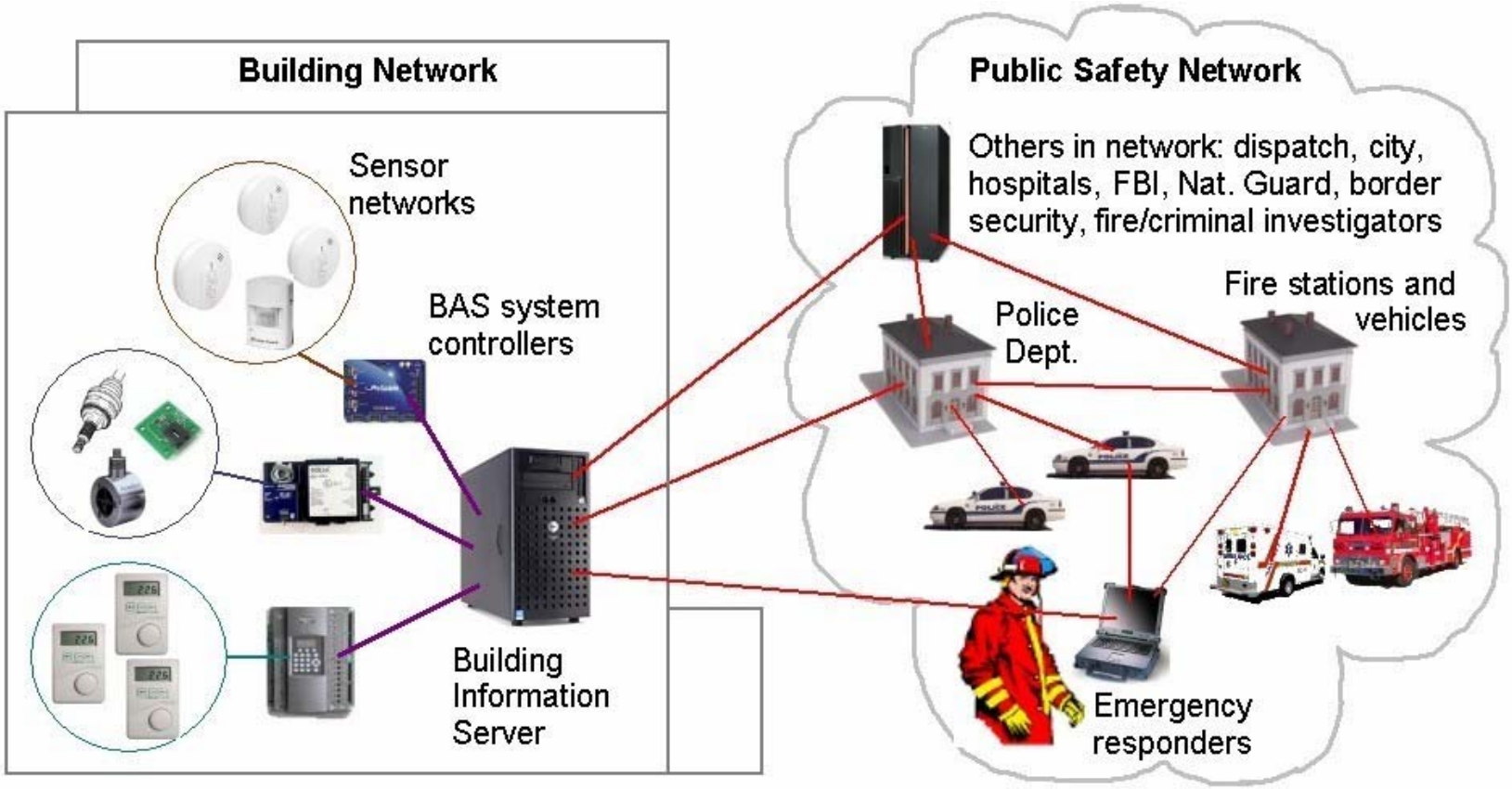
Considerable International interest:

- ISO TC178, U.K., Canada, Australia, New Zealand (disability regulations).
- Fire service access likely to be required by San Francisco for new high-rise.
- Key component of proposed, new philosophy of egress systems arrangements for tall buildings.
- Being incorporated in all new designs of buildings of significant height.

D. Building Equipment Standards & Guidelines

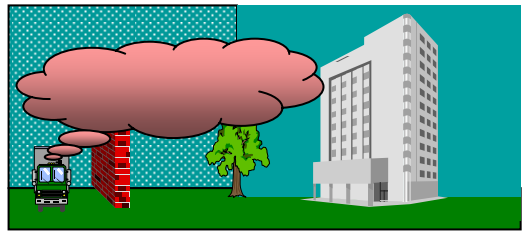
D1. Building Information During Emergencies

- Standard methods for managing heterogeneous wireless sensor networks in buildings, facilitating access by emergency personnel.
- Methods for ensuring secure dissemination of building information to emergency responders.



D. Building Equipment Standards & Guidelines

D2. Technologies for Building Operations in CBR Attacks



Develop analysis tools/guidance for assessment and reductions in vulnerability of buildings to CBR attacks.

- Extend capability to convert IFC-compliant CAD files into CONTAM files
- Analysis of enhanced filtration in context of building envelope airtightness & pressurization
- Participation in ASHRAE, ASTM, interagency activities

Retrofit options for commercial buildings:

- enhanced filtration
- gaseous air cleaning
- envelope tightening
- system shutdown and purge cycles
- system recommissioning

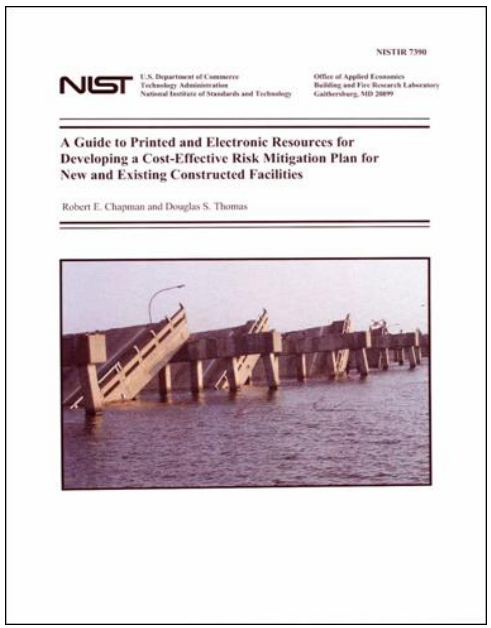

Building Ventilation And Pressurization As a Security Tool

D. Building Equipment Standards & Guidelines

D3. Cost-effective Risk Management Tools

Objective: Develop economic tools to aid facility owners/managers in selection of cost-effective strategies that respond to extreme events and reduce:

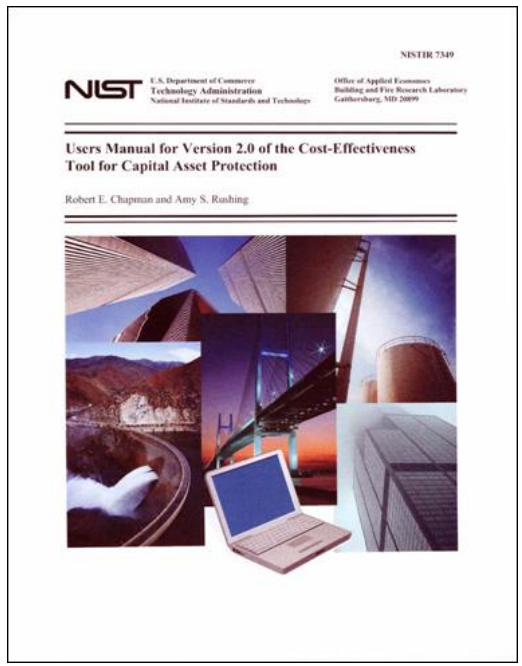
- fatalities and personal injuries
- financial losses
- damages to constructed facilities



Risk Mitigation Toolkit with web-enabled, annotated bibliography

ASTM E 2506 protocol

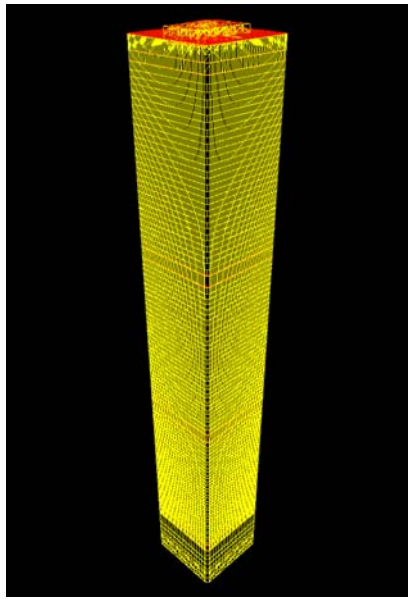
- ✓ Risk Assessment
- ✓ Risk Management
- ✓ Economic Evaluation



Cost-Effectiveness Tool for Capital Asset Protection using Life-Cycle Cost Analysis (ASTM E 917)

The Grand Challenge of the *Safety of Threatened Buildings Program*

Development of **whole building models** to enable performance evaluation of alternative engineering solutions for



A. increased structural integrity,
B. enhanced fire resistance,
C. improved emergency egress & access, and
D. building & emergency equip. standards & guidelines

that go beyond the requirements of the code to the point of failure, and to incorporate human behavior and economics into the mix.

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Acknowledgements

NIST Project Leaders:

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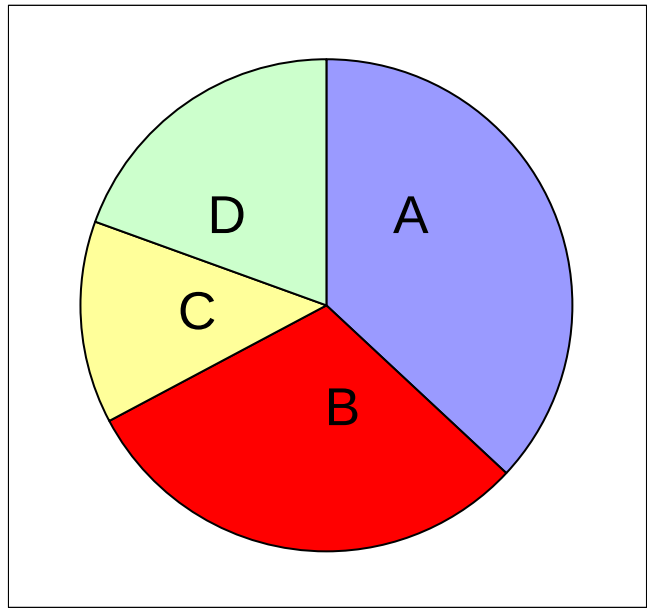

Funding breakdown

A. increased structural integrity
B. enhanced fire resistance
C. improved emergency egress & access
D. building & emergency equip. standards & guidelines